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# *The Part Taken by Teleutospores and AEcidia in the Distribution of Maize and Cereal Rusts.*

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The great economic importance to this country of the cereal rust question, and the hope of adding a little to the better understanding of some factors of the problem must be the excuse for the present paper. Among recent important advances in the study of the rusts causing injury to food-bearing grasses is the discovery of the æcidial stage of corn (maize) rust. Probably if the best informed botanists had been asked to suggest the most probable host for the corn æcidium, not one would have named the little unobtrusive woodsorrel. Yet observation supported by direct cultures has singled out this insignificant plant. Doubtless any member of the genus *Oxalis*, of which a few species grow in almost every localty, or at least in every region, is susceptible to the attack of corn rust. But the strangest fact in connection with the matter is, that while rust occurs upon corn almost or quite everywhere that corn is cultivated throughout the world, yet the æcidium has been rarely found, the number of recorded instances being less than a dozen, although these are in such widely separated regions as southern Africa, central Europe, and the upper Mississippi valley.

We have in the corn rust a closely analogeous case in kind and frequency of spore-forms to that of the black rust of wheat (*Puccinia poculiformis*), but the conditions for study are far simpler. Corn is a warm-region plant and wholly succumbs to the first cold of a northern winter. It cannot under any circumstances, therefore, enable the mycelium of the fungus to live over winter within its tissues, as there is a possibility for the black rust to do within the wheat plant, a possibility rarely or never accomplished it may be, unless far southward, but which, on the contrary, is

often accomplished with the equally destructive early rust of wheat (*P. rubigo-vera*). Furthermore, corn rust grows only upon corn, with the single exception of teosinte (*Euchlaena Mexicana*), a rather uncommon forage plant, not even affecting sorghum, as its Latin name would imply, or broom-corn, or the wild *Tripsacum*, all closely related plants. Schweinitz gave the name *Puccinia Sorghi* under the wrong impression that the fungus grew upon both *Sorghum* and *Zea*.

The restricted range of the parasite upon a single cultivated crop in its uredo and teleutosporic forms, and having all its stages of development known, should make it comparatively easy to trace the spread of the fungus, and to study the conditions for its propagation.

From the fact that the æcidial stage of the corn rust has been but rarely observed, I think that we may safely infer that this stage produces only a small part of the whole number of spores required for the general propagation of the species. Probably not one spore in ten thousand or even one in a hundred thousand produced during a season is an æcidiospore. To explain this paucity of æcidiospores we might fancy that the production of teleutospores, from which alone the æcidial stage can be produced, was also meager. But such is not the case, for probably a teleutospore is produced for every fifty or one hundred uredospores.

The general multiplication and distribution of the rust during the growing season unquestionably falls upon the uredospores. These are produced uninterruptedly from their appearance in July until frost interferes. Each spore as it attains full size drops away, is blown about by the wind, and upon striking a corn plant is ready to grow into it and establish another colony of the rust. The uredospores can, and undoubtedly do, blow long distances, probably many miles, and produce infection at remote points. It is quite possible, as it seems to me, that starting at some locality in the far south, where the absence of frost permits corn to grow the year round, as a stray, if not as a crop, and to harbor the rust, the uredospores may blow northward and cause succes-

sive infection in new localities as the season advances, and thus spread the rust throughout the country. This is the explanation offered by Bolley for the general diffusion of wheat rust, and it seems to me a very probable one and equally true of corn rust. In the case of wheat rust it might be assumed that the rust could be carried over winter on some wild grass, but in the case of corn the rust grows on no wild grass and we must look to the corn plant alone as the host.

That the spread of corn rust is almost wholly effected by the uredospores may be further inferred from the inefficiency of the teleutospores. When a teleutospore germinates, which it will only do in springtime, no result is produced unless the sporidia that are generated reach a plant of *Oxalis*, for direct infection of the corn plant is impossible. How long the sporidia will remain in growing condition, and to what distances they may be carried by the wind, are matters on which we are entirely ignorant, but which are of much economic importance and deserve to be investigated. Yet, nevertheless, whether from low vitality of the teleutospores, which keeps many from germinating, the short life of the sporidia, or their inability to carry infection over much distance, comparatively few æcidia are produced.

The few æcidiospores that are produced must necessarily restrict the number of centers of infection on corn plants derived from this source. It may be, however, that the few æcidiospores which find a successful entrance into the corn plant are more efficient in continuing the rust than an equal number of the uredospores would be for two reasons:

First, the æcidospore starts the rust earlier in the season than the uredospore is likely to do in the same region. The æcidia appear from the middle of May to the middle of June. Only a week is required to bring about the establishment of the rust in the corn plant with its crop of new spores ready to continue infection. Whereas, the first uredo infection from spores blown by successive stages from the south where the rust has wintered cannot be expected until after the first of July.

Secondly, the corn rust derived from the æcidiospore not

only has an earlier start, but a better start, than that derived from the uredospore, for, as I pointed out in a paper before this Society presented a year ago,* the fungus so produced has greater inherent vigor and a stronger parasitism, and consequently more power to injure the host, in this instance the corn plant.

Upon further examination into the reason for the superior vigor of the æcidispore over the uredospore, I have come to a slightly different conclusion to that presented in my former paper. I am aware that Blackman† has recently found certain movements of nuclei beneath the æcidium cup, which lead him to consider that structure a sexual organ, or the outgrowth of a sexual process; and from this it is natural to infer that the spores from a structure so so produced will have increased vigor. Whether Blackman's observations should bear the interpretation he gives them, or not, I cannot say, but nothing in my experience lends any direct testimony to the view so far as I can see. Were I to rewrite my former paper, I should name the spermogonium as a device for promoting the vigor of the fungus, rather than the æcidium. For I have observed that it is the spores which immediately follow the appearance of spermogonia that show the greatest increase of vitality, whether these be æcidiospores, uredospores or teleutospores. From this I infer that the physiological activity, supposed to result from a sexual act, emanates from the spermogonium, but whether or not connected in any manner with sexuality, it is impossible to say. It is, in fact, impossible at present to frame an acceptable theory of sexuality for the *Uredineae*, either those of economic importance, or any other.

I may now sum up the points that I desire to make. The corn rust is exceptionally well fitted for studying the spread of rusts on cultivated crops. This rust is chiefly spread by the uredospores. It starts in spring largely from uredospores blown in successive stages from the warm regions of the south. In a few places here and there it begins still earlier and more vigorously by the germination of over-wintered

†Am. Bot.
*Proc. Soc. Prom. Agr. Sci.

teleutospores first producing a crop of æcidiospores or wild plants of *Oxalis*, which in turn infect the corn plant. The appearance of rust on a plant does not imply that the source of infection is near by, for spores of some species of rusts, and notably those of cultivated crops, may blow long distances without losing vitality.

What is here said regarding corn rust is almost equally true, although not so clearly demonstrable, in the case of the black rust of wheat, oats and other grasses (*Puccinia graminis*), the crown rust of oats and some other grasses (*P. coronata*), and to some degree true of the brown rust of wheat, rye and other grasses (*P.* rubigo-vera).